Standards for Measuring Power Quality and Equipment Compatibility

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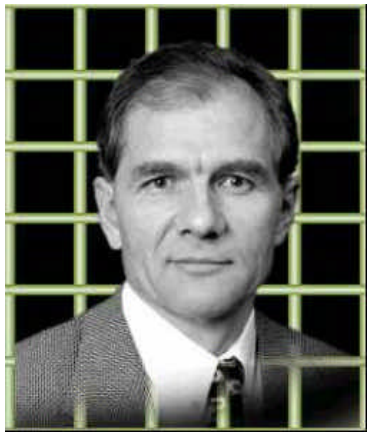


Comparison of Utility Standards defining "Quality of Service"

Worldwide consensus on the range for ac power characteristics seems to be growing.

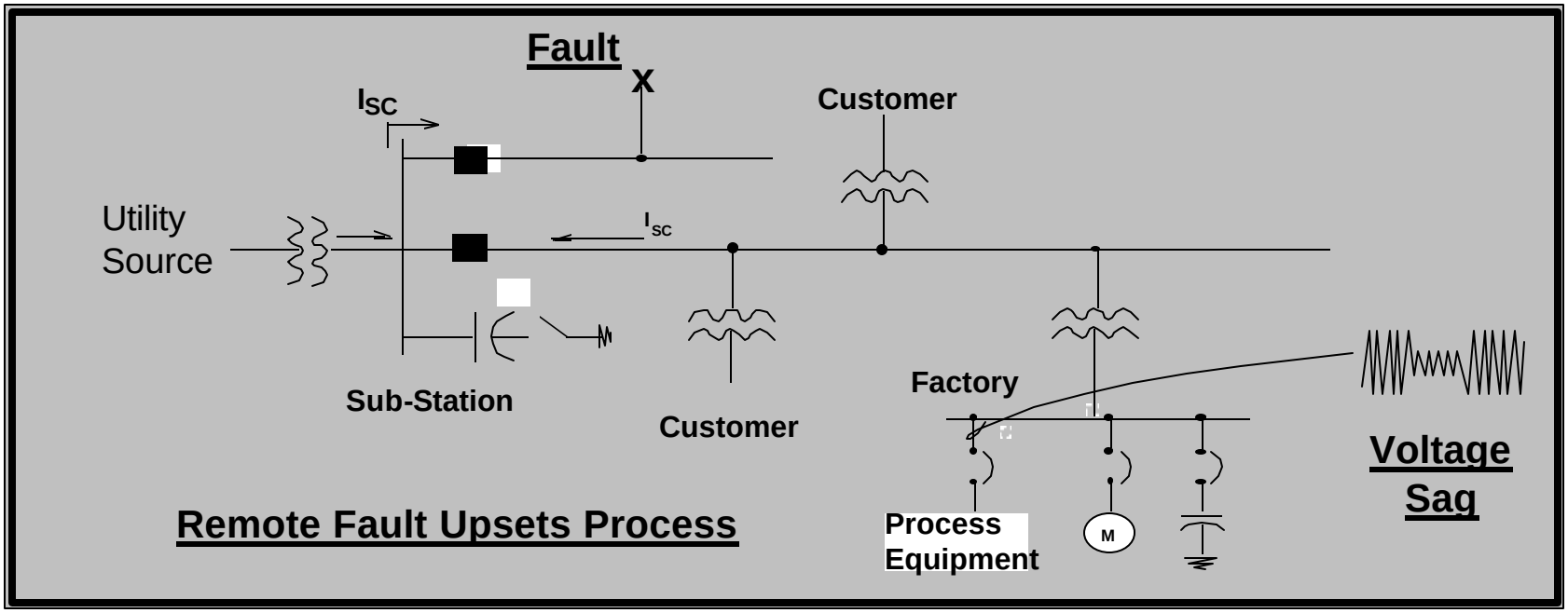
	IEC World	EN Europe	EDF France	IEEE/ ANSI	NER SA
Regulation	± 10%	± 10%	± 7%	+6, -13%	± 10%
Unbalance	2%	2% (3%)	2%	3%	2% (3%)
Harmonics (V_{THD})	8%	8%	8%	5%	8%
Harmonics detail	IEC	IEC	IEC	IEEE 519	IEC
Inter-harmonics	(0.2%)	-	-	-	(.5%)
Flicker	Plt=1.0	Plt=1.0	Plt=1.0	519 curve	Plt=1.0
Interruptions (short)	-	-	-	-	-
Interruptions (long)	-	10 to 50	8	-	2-60
Voltage Dips or Sags	-	10s to 1000	-	2	XYZ
Frequency (grid)	2%	1%	1%	1%	2.5%

IEC Standards Related to Momentary Sags/Dips, Interruption

- *61000-2-1* Description of EM environment, low-frequency conducted
- *61000-2-4* Compatibility levels in industrial plants low-frequency conducted disturbances
- *61000-2-5* Classification of EM environments
- *61000-2-8x* Voltage dips and short interruptions, Stats
- *61000-3-3* Limits on equip fluctuations < 16A
- *61000-3-5x* Limits on equip fluctuations > 16A
- *61000-4-1* Overview of equip immunity tests
- *61000-4-11* Basic immunity tests for dips, interruptions for equipment less than 16 amps
- *61000-4-14x* Basic immunity test methods for voltage fluctuations, unbalance and freg.variations

And Still We See Many "Incompatible Pairs"

- *Faults and Sags* *and* *Process Equipment*
- *Voltage Surges* *and* *Microprocessors*
- *Current Harmonics* *and* *Power Transformers*
- *Capacitor Switching* *and* *Adjustable Speed Drives*

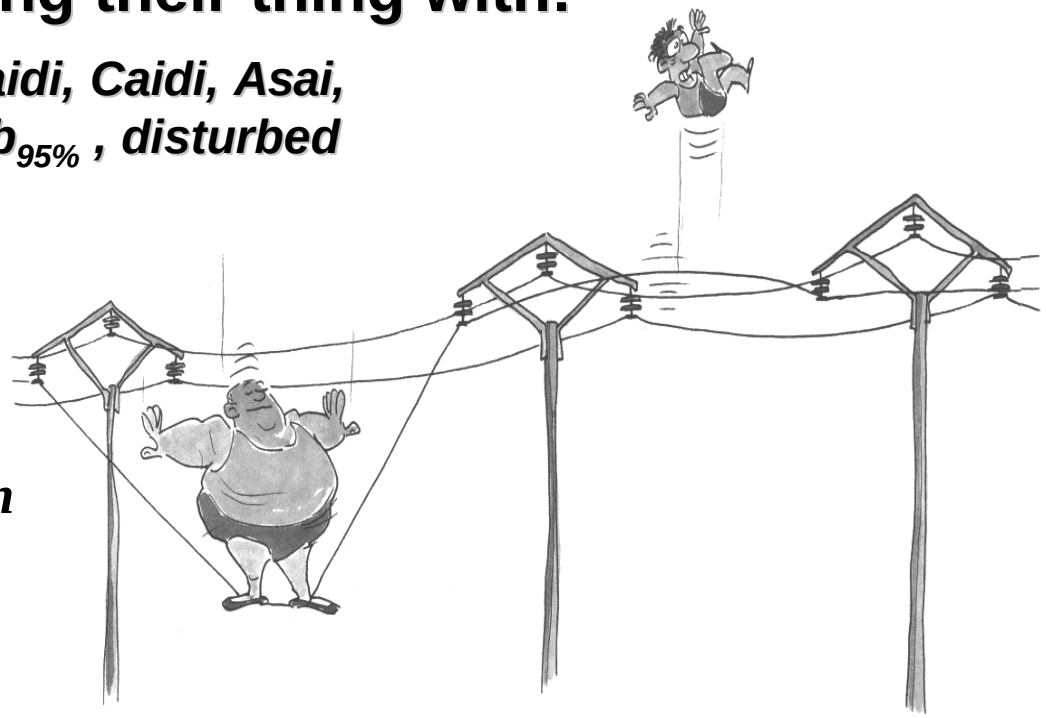


Realities of power, equipment and incompatibilities

- **Designers agree that their equipment works well with perfect power**
- **Customer engineers are focused on recovery from yesterday upsets or today's installations**
- **Utilities are doing their thing with:**

DPQ study, Saifi, Saidi, Caidi, Asai, Maifi,Sarfi, CumProb$_{95\%}$, disturbed levels, RBM, etc.

We have some big challenges in customer communication and agreements!



System Average RMS (Variation) Frequency Index — $SARFI_{\%V}$

- Number of specified short-duration rms variation per system customer
- Voltage threshold allows assessment of compatibility for voltage-sensitive devices

$$SARFI_{\%V} = \frac{\sum N_i}{N_T}$$

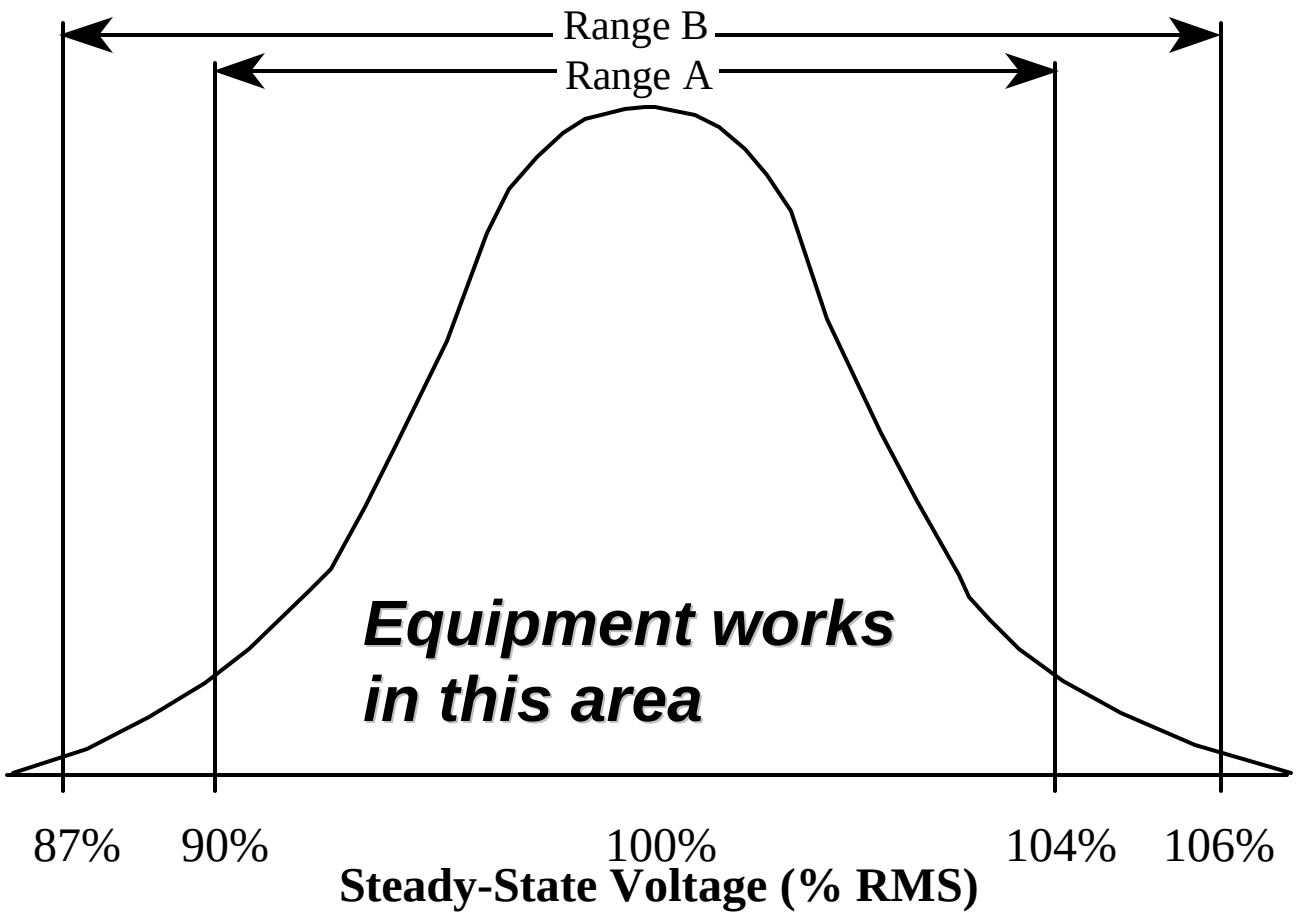
$\%V \equiv$ rms voltage threshold
140, 120, 110, 90, 80, 70, 50, 10

$N_i \equiv$ # customers experiencing rms < $\%V$ for variation i
(rms > $\%V$ for $\%V$ >100)

$N_T \equiv$ total # system customers

The Electrical Environment:

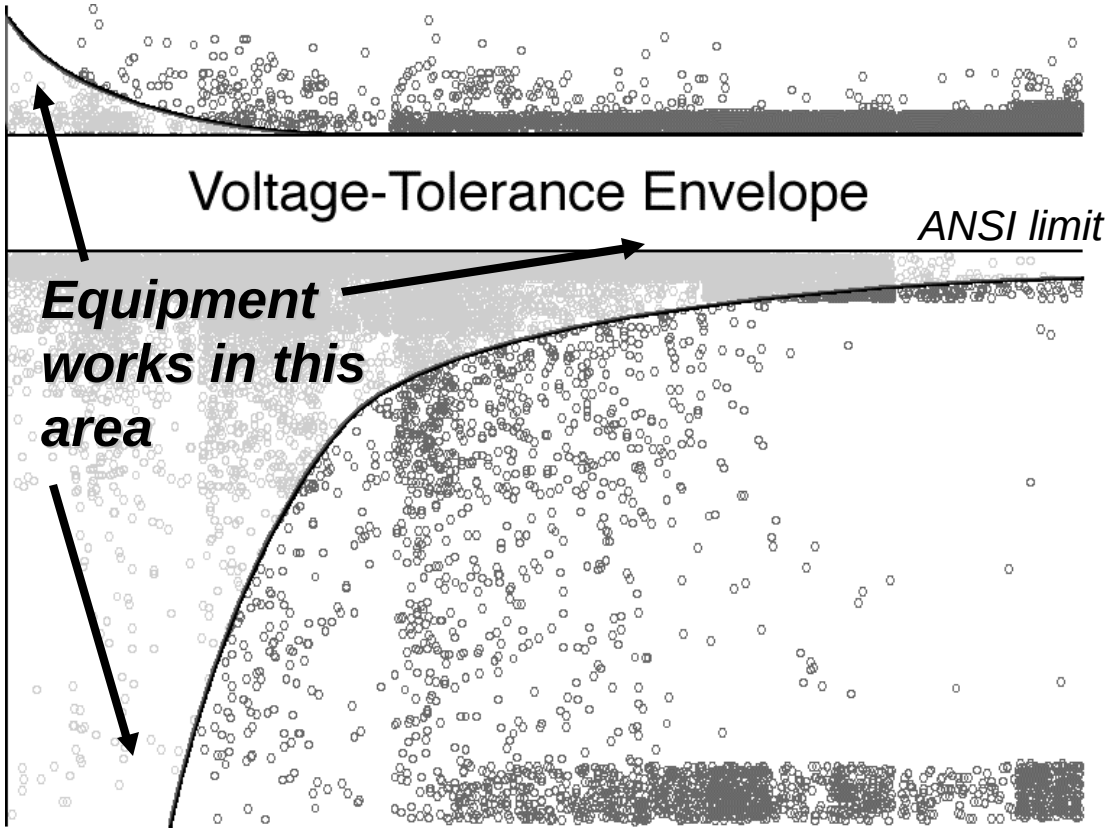
— back to understandable expectations



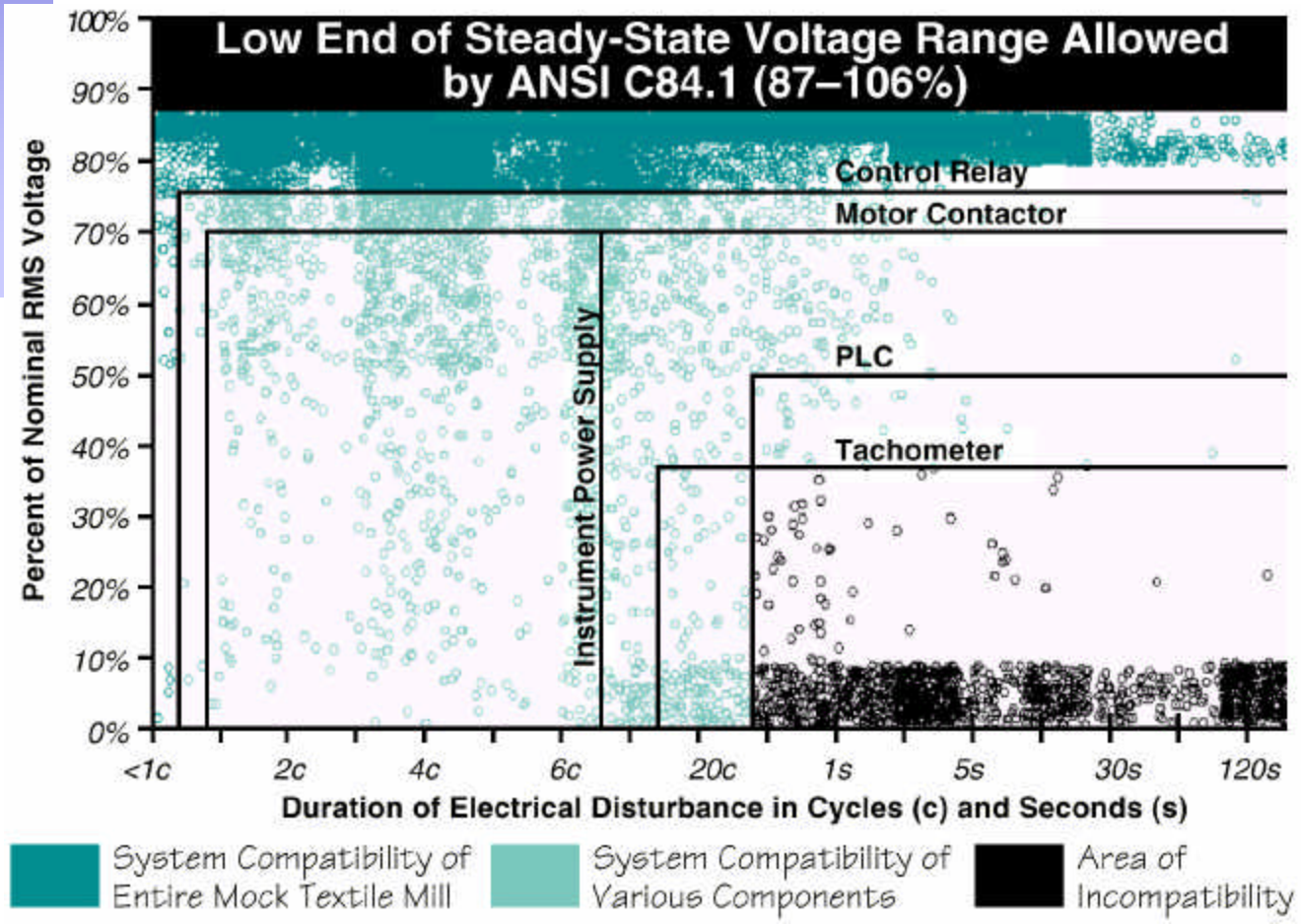
- ANSI C84.1-1970, steady-state probability curve

Building a bridge to equipment manufacturers

- ***The Goal: To influence standards and manufacturer design goals***
- ***The Reality: System Compatibility Profile***

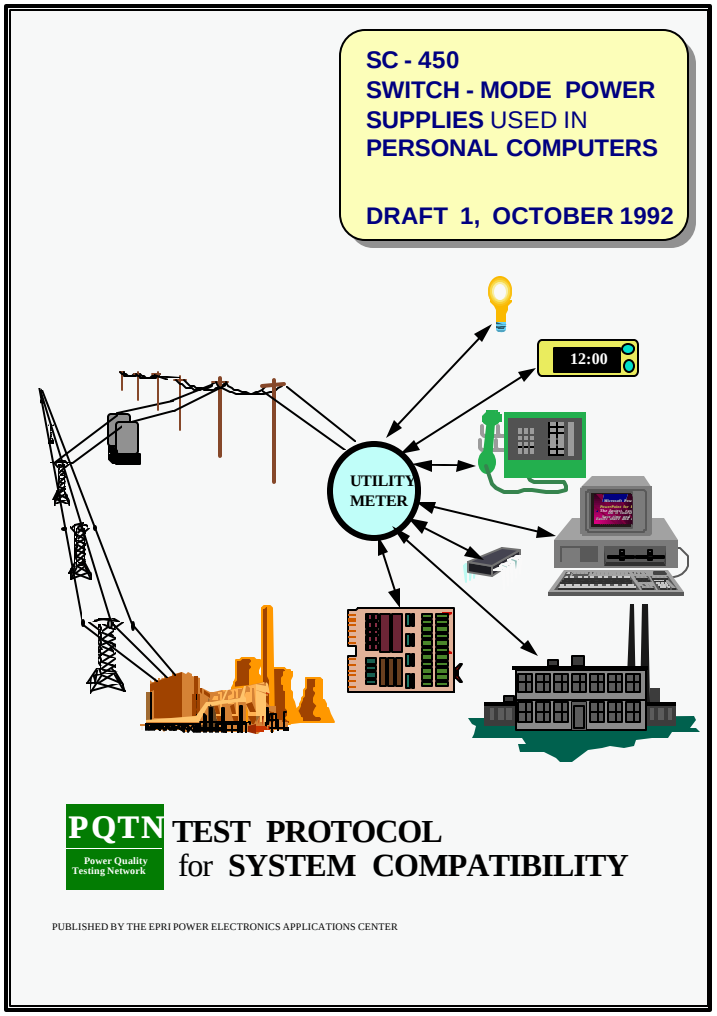


How do power supplies compare



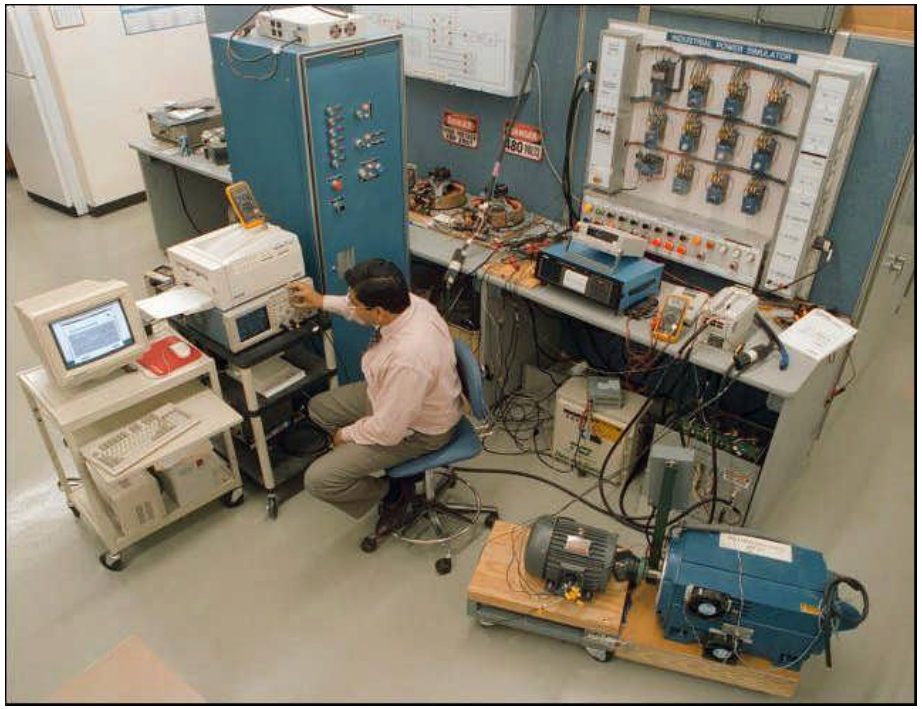
Basic Approach to End-User Equipment Testing

- Required Steps
- Define a baseline electrical environment
- Create test protocols and performance criteria
- Characterize electronic appliances (with manufacturers' help)
- Develop generic "System Compatibility Profiles" for appliances categories

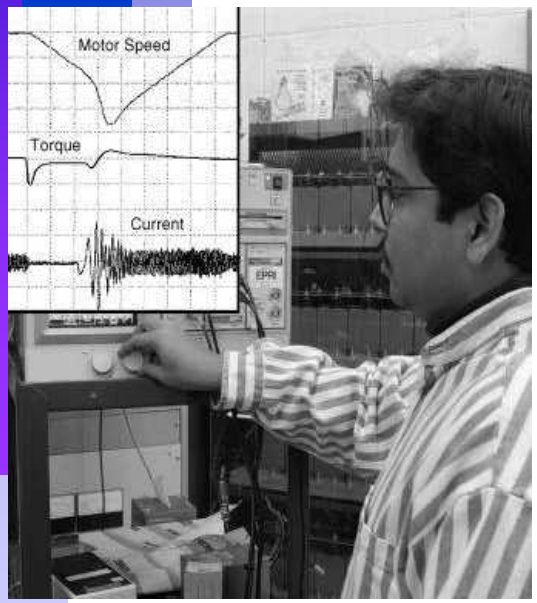


System Compatibility Research — for Industrial

- ASD, PLC, Servos
- Motors with variable torque loading
- Industrial ride thur devices
- MCC's and control logic
- CNC machines,
- Sensors

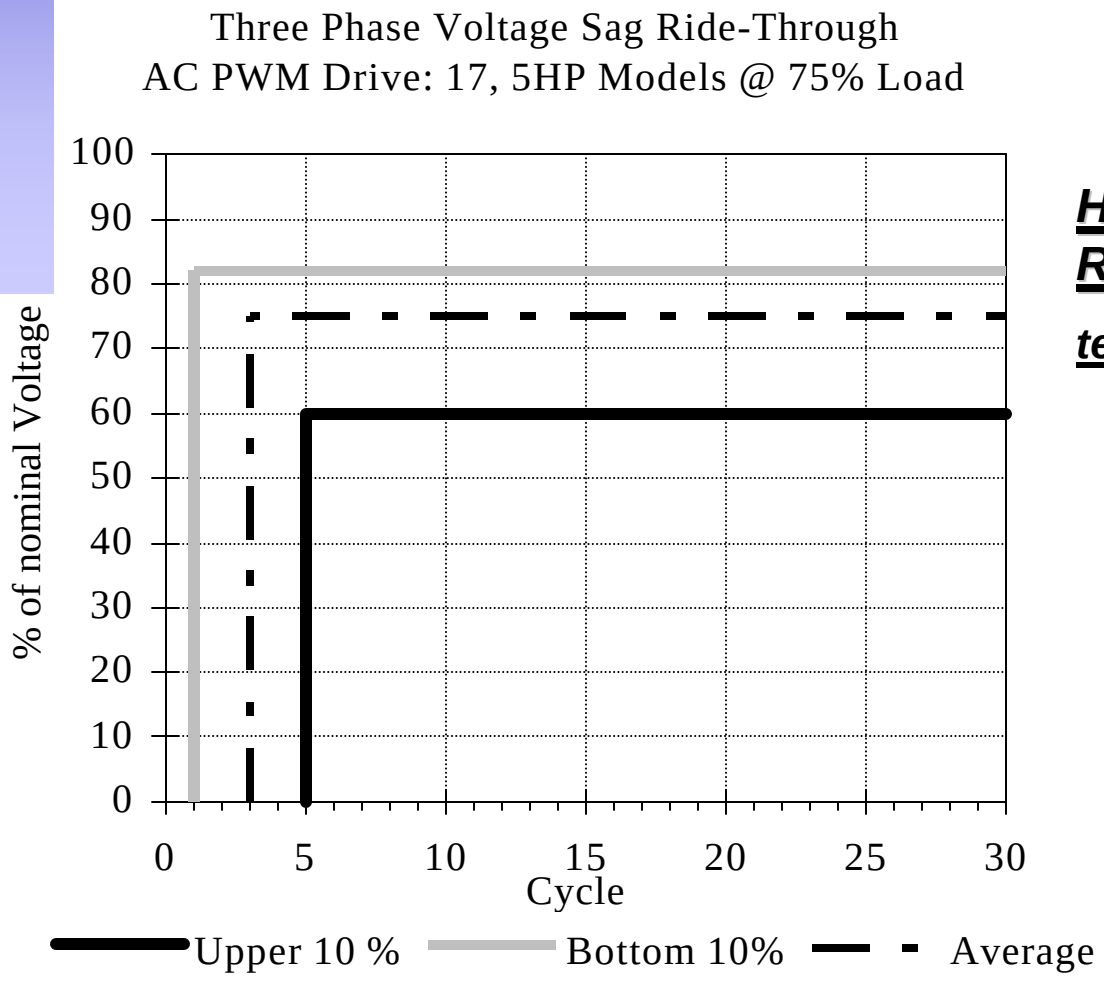


Understanding what goes on inside an Adjustable Speed Drive



Consequences of a 2-cycle interruption

Summary of 17 Drives

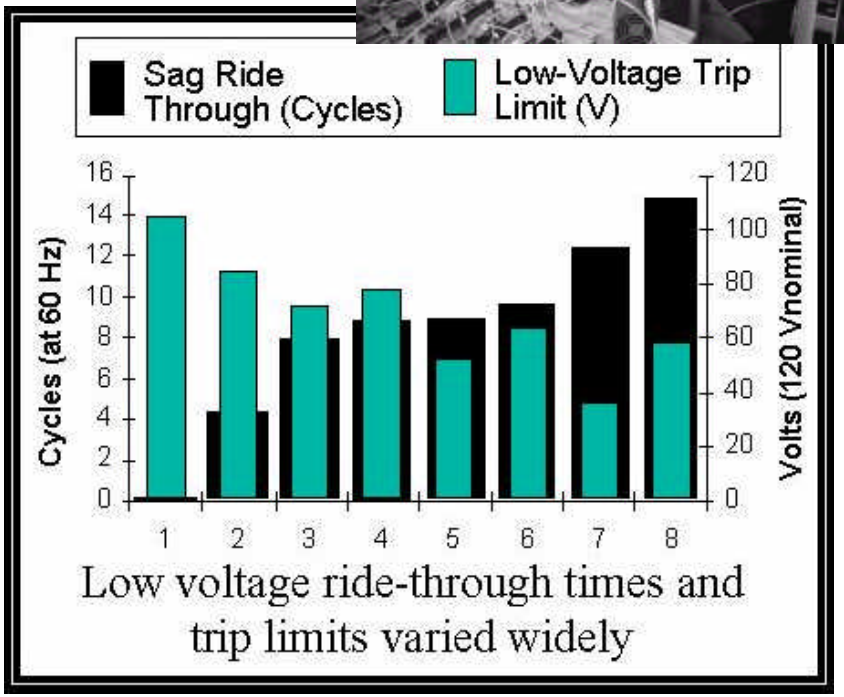


How 17 Drives Responded

test sag	***6/50%***	***10/30%***
A	***1***	***10***
B	***3***	***2***
C	***8***	***3***
D	***5***	***2***
# ASDs	***17***	***17***

Manufactures of Electronic Products Respond to Test Results

- ***For computers*** *- Based on power supply tests CBEMA approved new curve*
- ***For ballasts*** *- Based on tests ANSI/ NEMA C82 standardized on voltage sensitivity and harmonic limits*
- ***For ASDs*** *- Based on test results ASD manufacturers are looking at name-plating for sag responses*



Low voltage ride-through times and trip limits varied widely

Opportunities to Bring About Better Compatibility